

*Length* of ♀ 4 to 4·5 mm. ; of ♂ 3·5 mm.

*Habitat*.—South America and India generally.

*Observations*.—I can see no difference between the Indian and South American specimens. The insect is very marked, and can at once be told by its densely-scaled dark mottled wings and leg tufts.

Genus *Uranotenia*. (Arribalzaga.)

‘Dipt. Argentina,’ p. 63 (1891), Arribalzaga ; ‘Mono. Culicid.,’ ii, p. 241 (1901), Theobald.

Told from other *Aedes* by the presence of flat scales on the mesothorax and scutellum, swollen mid femora, and by the very small fork-cells. A single species represented by two ♂’s has been found in India.

*Uranotenia minima*. (Theobald.)

‘Mono. Culicid.,’ ii, p. 262 (1901).

Thorax deep brown (denuded), with long black bristles ; metanotum with a pale median line. Abdomen dark brown, with narrow basal bands of pale yellowish-brown ; pleuræ and coxæ very pallid.

*Length*.—1·8 to 2 mm. (♂).

*Habitat*.—Quilon, South India.

*Observations*.—I have only seen two ♂’s of this species, both denuded of scales. They are, however, I feel certain, *Uranotenia*, but the fork-cells are a little longer than usual in this genus.

“The Application of the Kinetic Theory of Gases to the Electric, Magnetic, and Optical Properties of Diatomic Gases.” By GEORGE W. WALKER, B.A. Communicated by Professor RÜCKER, Sec. R.S. Received January 23,—Read February 14, 1901.

(Extended Abstract.—Received January 6, 1902.)

In this paper I have endeavoured to examine the most important magnetic, electric, and optical properties of a gas, supposed to consist primarily of two-atom molecules. A two-atom molecule, in which the atoms are of unequal mass and carry equal and opposite electrical charges, was selected not as an actual representation of the molecule, but as typical of the characteristic features. I have adopted Boltzmann’s distribution law, and, as far as I can judge, have not applied it beyond the limits to which it appears to be justified experimentally.

We have first to observe that the molecules may be divided into three classes, which I have called A, B, and C.

In A the two atoms revolve in continuous contact under their mutual electric attraction; in B and C they are separated by the centrifugal tendency. In B the two atoms are describing elliptic orbits about their common centre of inertia, while in C they describe hyperbolic or parabolic orbits. In the set C the atoms may thus be regarded as practically free. We may also contemplate the possibility of multiple molecules.

The individuals of the three fundamental sets may change from time to time; but we may suppose that a permanent average distribution will finally obtain.

The proportions of molecules in the three classes must be determined by the consideration that the velocities satisfy the conditions appropriate to the specified class. There is no discontinuity in the case of B and C, and the limits of integration for these have been determined. I have not obtained a satisfactory estimate of the proportion of A to B, as a sort of discontinuity occurs. Inasmuch as the electrical energy of the two atoms when close together is very great compared with the mean kinetic energy at ordinary temperatures, the molecules are mainly of the class A.

It has thus been established that a small proportion of molecules are always dissociated, a point which has recently been established experimentally. I also find that although on the whole the numbers of B and C together diminish as the pressure decreases, yet the proportion of C to B increases as the pressure decreases. This would account for the increased ease with which electrical discharge takes place through a gas under reduced pressure.

Passing next to the magnetic properties it is shown from a former paper\* that diamagnetic effects are produced by the free atoms on establishing a magnetic field, and that the effect disappears very soon. It is also shown that the molecules contribute positive magnetic susceptibility; and the formula obtained, which is complicated, agrees well with Quincke's experiments on the subject.

Turning to the dielectric constant, it is found that

$$K = 1 + k p / \theta^2,$$

where  $p$  is the pressure,  $\theta$  the absolute temperature, and  $k$  is a constant depending on the gas. This differs essentially from other theories which have been proposed, as regards the temperature variation, the usual result being

$$K = 1 + k p / \theta.$$

We may see without analysis how this arises. The electrical field is capable of affecting the rotational energy of the molecule, and thus the

\* "On the Phillips Phenomenon," 'Electrician,' August, 1899.

control depends on the temperature; whereas in all former theories the control is supposed to be independent of temperature.

The calculation of  $K$  applies to two-atom molecules, but it is clear that a similar result will hold for a more complicated molecule, provided that the energy of those co-ordinates, which are affected by an electrical field, can be affected by the communication of heat.

I have next considered the optical effects. The free atoms are first considered, and the method used is due to Lord Rayleigh, viz., calculating the effect of the waves on the particles, and then the modification of the waves, which these disturbed particles produce.

The motion of a free atom under the influence of plane waves can be completely determined, and the results are as follows: Each atom moves in a complicated manner, but as a first approximation the motion may be regarded as made up of a linear motion and a periodic motion. For any individual atom this periodic motion is not parallel to the plane of the waves, nor is it strictly of the same period as the incident waves; but on integration for the whole set, the component normal to the plane of the waves vanishes, and only the component in the plane of the waves remains. The free atoms accelerate the velocity of propagation by a term proportional to the square of the wave-length, and hence the refractive index is diminished by the same term. This is identical with the term introduced by Ketteler in Cauchy's formula to explain the observed facts in cases of abnormal not anomalous dispersion. The atoms scatter the light, and consequently the intensity of the transmitted light is diminished, but the effect is independent of the wave-length.

With respect to the molecules, it is found that a new distribution law obtains, the change being of such a nature that there is a periodic orientation of the axes of the molecules and a periodic surging of the centres of inertia of the molecules in the plane of the waves. Both effects contribute to the refractive index, but the former is of far greater importance than the second. The final result, which involves a function of considerable complexity, is shown to be capable of explaining ordinary or anomalous dispersion.

The formulæ for  $K$  and  $\mu$ , which agree in giving  $K = \mu_{\infty}^2$ , are considered in their bearing on the supposed additive law. They would not give a strictly additive law, but the divergence would not be great if the properties of the constituents were not widely different. They agree with an additive law as well as experiment warrants.

The coefficient of rotation of the plane of polarisation in a magnetic field is obtained, and is found to vanish if the masses of the positive and negative atoms are equal. Combined with the formula for refractive index an estimate of  $\bar{\omega}$  for oxygen is obtained,  $\bar{\omega}$  being called the angular velocity of rotation of mean square, from analogy with the ordinary velocity of mean square.

I may now quote from the paper my conclusions : \* “ It is interesting to note that  $\bar{\omega}$  [here] plays the part of a control in refraction, and that the form of the dispersion curve is really due to the distribution law and not to radiation. The value of  $\omega/2\pi$  obtained must be about three times the frequency for the Na lines and hence  $\bar{\omega}$  corresponds to a frequency far beyond the violet. I see no grave objection to this result, as the same result would arise in any theory in which a single term is supposed to represent the facts. The controlling period must be less than the imposed period to explain ordinary dispersion in the spectral range.

“ The high value of  $\bar{\omega}$  precludes the possibility of explaining spectral lines by the molecules of this theory. I am inclined to think that spectral lines are in some way connected with dissociation, but not necessarily of simple molecules.

“ I return to a suggestion which I made earlier, that these are due to multiple molecules. We cannot avoid the conclusion that there are such in a gas. They need not, and indeed do not, have a permanent existence. It is only necessary that there should be a small proportion on average. The frequencies of these small planetary systems are probably less than the frequency of the molecule *par excellence*. Further it is probable that their frequency will not be greatly affected by pressure, but the number would probably increase with pressure. This would agree with Professor Sir Norman Lockyer’s observations that the period of the lines does not alter much with pressure, but the intensity does increase considerably with increase of pressure.”

Earlier in the paper I point out the importance of multiple molecules in connection with the theory of the ratio of specific heats. “ The ratio of specific heats for chlorine indicates more nearly six degrees of freedom, and one must either suppose that there is a considerable proportion of the set B present, or else a proportion of multiple molecules. The first supposition could hardly be supported quantitatively on electrical grounds ; while the second is more probable in view of the comparative proximity of chlorine, under ordinary conditions, to its critical state.”

*Note.*—In the Thesis presented to the University of Göttingen, for his doctorate, Herr Karl Baedeker has measured the effect of temperature on the dielectric constant for several gases. The thesis was published in pamphlet form in August, 1900, and in the ‘*Zeitschrift Phys. Chem.*,’ vol. 36, pp. 305–335. The bearing of his results on the formula above given is analysed in the following table,  $\theta$  being taken as temperature centigrade *plus* 273°·3.

\* These views were first expressed in a Fellowship Dissertation presented to Trinity College, Cambridge, in August, 1900.

## Sulphur Dioxide Gas.

Temperature C.	Baedecker's value of K (observed).	Calculated by formula $K = 1 + k p/\theta^2$ .	Calculated by formula $K = 1 + k p'/\theta$ .
0	..	1·00999	1·00962
10·3	1·00928	(1·00928) basis	(1·00928) basis
16·4	1·00893	1·00889	1·00908
21·6	1·00869	1·00858	1·00892
37·5	1·00794	1·00772	1·00846
42·2	1·00765	1·00749	1·00834
49·4	1·00734	1·00716	1·00815
64·1	1·00669	1·00655	1·00780
76·1	1·00634	1·00611	1·00753
103·3	1·00551	1·00525	1·00698

## Ammonia Gas.

0	..	1·00831	1·00779
18·4	1·00730	(1·00730) basis	(1·00730) basis
19·0	1·00704	1·00726	1·00728
59·4	1·00547	1·00561	1·00640
62·1	1·00538	1·00552	1·00634
83·8	1·00482	1·00486	1·00596
95·3	1·00453	1·00457	1·00577
108·4	1·00434	1·00426	1·00557

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*February 6, 1902.*

Sir WILLIAM HUGGINS, K.C.B., D.C.L., President, in the Chair.

His Royal Highness the Prince of Wales (elected June 8, 1893), was admitted into the Society.

A List of the Presents received was laid on the table, and thanks ordered for them.

The following Papers were read:—

- I. "The Stratifications of Hydrogen." By Sir WILLIAM CROOKES, F.R.S.
- II. "Radio-activity and the Electron Theory." By Sir WILLIAM CROOKES, F.R.S.
- III. "The Density and Coefficient of Cubical Expansion of Ice." By Dr. J. H. VINCENT. Communicated by Professor J. J. THOMSON, F.R.S.